E7.4-10729
CR-139575

(E74-10729) EXPERIMENTAL EVALUATION OF ATMOSPHERIC EFFECTS ON RADIOMETRIC MEASUREMENTS USING THE EREP OF SKYLAB Quarterly (Environmental Research and Technology, Inc.) 13 p HC $4.00 CSCL 14B G3/13

N74-31808

Unclas 00729

EXPERIMENTAL EVALUATION OF ATMOSPHERIC EFFECTS ON RADIOMETRIC MEASUREMENTS USING THE EREP OF SKYLAB (EPN No. 439)

Contract No. NAS 9-13343

Prepared by

David T. Chang
Principal Investigator

Fifth Quarterly Progress Report
May 1974 - July 1974

Submitted by

ENVIRONMENTAL RESEARCH & TECHNOLOGY, INC.
429 Marrett Road
Lexington, Massachusetts 02173

Contract Monitor:

Larry B. York, Code TF6
Principal Investigations Management Office
NASA - Lyndon B. Johnson Space Center
Houston, Texas 77058

EXPERIMENTAL EVALUATION OF ATMOSPHERIC EFFECTS ON RADIOMETRIC MEASUREMENTS USING THE EREP OF SKYLAB

1. Program Summary

At the present time we are awaiting the results of the evaluation of our recently submitted proposal to extend the present contract.

2. Work Accomplished During the Reporting Period

In addition to the preparation of a proposal in response to a request from the Contracting Office (RTAO: BB631 B4), three other tasks were performed during the reporting period. These include:

a. Completion of an "interim" final report to review and summarize the work completed for the year's period commencing 7 May 1974. This document was submitted along regular channels to the technical monitor.

b. A comprehensive evaluation of the information received at the recently held SKYLAB EREP Principal Investigators Data Meeting with particular attention to how this study will be effected by problems encountered with the data. Conclusions drawn from this evaluation are summarized in Section 3.

c. Study of the theoretical model adopted to compute atmospheric effect including a comparison of some preliminary calculations with S191 digital data. These results are included in Section 4.

3. Evaluation of Material From the PI Data Meeting

In a series of meetings and discussions with J. Barnes and J. Willard who attended the meeting and through study of the printed material received, a comprehensive evaluation of the impact of data/instrumental problems on fulfilling the scientific objectives of this study was undertaken. The results of this study are summarized by instrument.

3.1 S190 A Multispectral Camera - S190 B Earth Terrain Camera

Since data from these photographic instruments is utilized entirely to document the areal homogeneity of surface targets, anomolies such as streaks electrostatic marking, fogging, and emulsion lifting are of little consequence. These imperfections do not prevent imagery from being used to seek homogenous areas since for the most part, they are readily distinguishable against desert-like backgrounds.

3.2 S191 Interferometric Spectrometer

Data from the long wavelength (LWL) portion of the S191 Spectrometer scan was to have been used to deduce ground-truth data of atmospheric structure over the selected target sites. In addition, since the selected test site area was generally acquired up to 45° ahead of nadir, an effective viewing angle scan was performed by the astronaut as the site was kept within the instrument field of view providing a means of examining the angular isotropy of surface reflectance (to validate the Lambertian assumption made in the theoretical treatment) in the short wavelength (SWL) portion of the data. Examination of the instrumental error problems encountered leads us to believe that the LWL data may not be suitable for inferring vertical atmospheric structure. Absolute accuracies cited are ~15% in the SWL and thermal regions.

Of the problems cited in "S 191: Cautionary Note for Data Processed According to Photr 524 CH 2" forwarded to PI's recently, the most significant to our study is that of off band radiation. Atmospheric vertical structure (particularly the water vapor profile) should be obtainable from radiance measurements made in the 6-8 μm (6.7 μm H_2O Band) and 14-15 μm (15 μm CO_2 "hot" Bands). However, such inversion procedures are very sensitive to noise in the data. Since the offband radiation problem seems to become critical in precisely these absorption band spectral regions, it does not seem feasible to use the data for this purpose. The only recourse is to account for site atmospheric parameters using nearby conventional meteorological data. Climatology would probably provide better results than extremely noisy inversions. Due to cool down problems, there is no useful thermal data for Passes 2 or 5 which include both ground-truth test sites.

Data in the SWL region is affected by both calibration and off-band radiation problems, but appears to be useable in the region from .45 μm - 2.00 μm. Data from an acquired test site (Pass 43, Salton Sea Desert) for a period of ~3.7 seconds shows no apparent change in measured radiance with viewing angle. (See Figure 4.) However, these plotted data are not corrected for atmospheric effects.

3.3 S192 Multispectral Scanner

The low frequency and high frequency noise filtering techniques which have been developed are certainly more than adequate to satisfy the data requirements of this study. In selecting an areal segment of S192 digital data for analysis, areal averaging will most likely be done at a resolution of ~25-35 km over the homogeneous targets selected for study, this averaging will provide good characteristic numbers.

The only serious impact due to S192 anomolies involves the loss of data during Pass 2 due to improper spectral alignment and Pass 5 since C/D/P was not properly seated. Fortunately, alternate segments (Passes 39 and 43) were requested for these sites, but simultaneous ground truth has been lost.

4. Preliminary Theoretical Results

Theoretical values for the S192 channel radiances are calculable from the expression:

$$R^i\ (a,b,c) = \frac{1}{\pi}\int_{\lambda_1^i}^{\lambda_2^i} I(\lambda)\ \phi^i\ (\lambda)\ [T_\theta\ (\lambda)\ r\ (\lambda)\ \sin\theta\ (aT_Z(\lambda) - b) + cJ_\theta\ (\lambda,r)]\ d\lambda$$

Radiances at zero air mass (such as are measured by aircraft ground truth) are similarly calculated by assigning unit transmissivity to the atmosphere on the exit path. The difference between the theoretical radiance and the zero air mass radiance is the atmospheric correction for the channel.

where: (Sources and references in brackets)

1) Superscript i refers to a particular S192 channel with wavelength limits specified by $(\lambda_1^i, \lambda_2^i)$: i = 1,2,3. . ., 13.

2) Parameters (a,b,c) identify the calculated intensity R^i in the following manner:

R^i (1,0,1) = theoretical S192 channel radiance

R^i (0, -1,0) = Theoretical "zero air mass" radiance

R^i (1,1,1) = R^i (1,0,1) - R^i (0,-1,0) = atmospheric correction

3) $I(\lambda)$ = solar irradiance spectrum (watts m^{-2} μm^{-1}) [Thekaekara, 1970]

4) $\phi^i(\lambda)$ = S192 $i^{\underline{th}}$ channel spectral responsivity [NASA-JSC, 1973]

5) θ = solar elevation angle for the particular test site geometry

6) $T_\theta(\lambda)$ = atmospheric transmissivity from surface to space at angle θ

$T_Z(_\lambda)$ = zenith atmospheric transmissivity [Selby and McClatchey, 1972]

7) $r(\lambda)$ = surface reflectance spectrum [ground truth and/or Hunt et al, 1970-1974]

8) $J_\theta(\lambda,r)$ = atmospheric diffuse reflectivity at angle θ and for surface reflectance r [Fraser, 1973 and Plass and Kattawar, 1968]

These computations provide not only for immediate magnitude comparison with actual S192 radiances, but allow interchannel (differential) spectral effects to be evaluated.

Simulated S191 data may be obtained by evaluating only the integrand as a function of wavelength while assigning the response function an effective value of 1.0 at all wavelengths.

A sample calculation made with this scheme is illustrated in Figures 1, 2, 3. Figure 1 lists the input parameters used in the evaluation of the equation for radiance. The solar zenith angle is 37.55°. A summer mid-latitude atmospheirc model was chosen with a 23 km visual rangle haze model. Atmospheric transmissivity (4 & 5) is calculated as a function of wave-number (1 & 2). Columns 3, 6, 7 are input, column 7 being carefully chosen to

compliment the atmospheric model and viewing geometry.

Unit band pass (i.e. square response function centered at given wavenumber) quantities are given in Figure 2. Columns 1a, 1b, 1c are, respectively: theoretically satellite measured radiance, air craft (low flying) measured radiance, and atmosphereless radiance. This last quantity represents the radiance measured in the total absence of an atmosphere i.e., the reflectance spectrum of an identical surface area element illuminated by solar radiation in identical viewing geometry at the top of the atmosphere. Column 2 is the correction which must be subtracted from a satellite measurement to give the radiance which would be measured by an earth resources aircraft. Columns 3 b & c are the surface reflectance changes corresponding to the atmospheric effect over the zero air mass and atmospheric effect over the zero air mass and atmospheric cases, respectively. The larger this number is $|$ Abs. Mag.$| \leq 1$, the greater the atmospheric effect. Some of these data (3b) are plotted in Figure 5. Note that the effect of Rayleigh scattering is significant, while the aerosols form a continuum. Column 4 would be input data of actual measurements if any [here (4)=(1a)] and Column 5 is the measured data corrected by Column 2 [in this case (5) = (1b)].

In Figure 3 these results are integrated over the S192 filter response functions which the program stores internally. The tabulated quantities are analougous to those in Figure 2 differing only in their bandpass weighting. The column labelled "GNUBAR" refers to the filter function centroid wavenumber as calculated from the stored filter function. Here again, the "MEASURED RADIANCE" column is a dummy set equal to the theoretical value since no data was available.

The results of these calculations (Figs. 2 and 3) and plotted in Figure 4 and compared to three time segments of S191 data from Pass #3 over the Salton Sea Desert. Note that the calculated values are too large by a factor of 10 (they are plotted as multiplied by 10^{-1}). The reason for this discrepancy is not known. The S191 data was taken from an Intermediate Radiance Parameters Tabulation (Product S042-3). The theoretical curve is somewhat low in the visible (.4-.7 μm), but this is undoubtedly due to the low visible reflection spectrum assumed for the surface (~ .20).

The column labelled "SURF. REF. CHANGE - ZERO AIR MASS" provides a measurement of the atmospheric correction which must be made in surface reflectance determinations to interpret space platform - based multi-spectral data in times of low altitude aircraft measurements. As expected the most significant atmospheric effect is in the visible and slopes down into the rear infrared. (Note that since only a few points are plotted, the effect of narrow absorption lines is not seen in the data.

5. Significant Results

Since the calculations are of a preliminary nature there are no significant results to report at this time.

6. Further Plans

Further analysis will await receipt of requested data.

BIBLIOGRAPHY

Fraser, R., 1973: Computed Atmospheric Effects on ERTS Observations, NASA ERTS Symposium, Washington, D.C.

Griggs, M., 1973: Determination of Aerosol Content of the Atmosphere, NASA ERTS Symposium, Washington, D.C.

Hunt, G. R., J. W. Salisbury, C. J. Lenhoff, (1970-1974): Visible and Near Infrared Spectra of Minerals and Rocks, I-IX, Modern Geology.

Plass, G. N. and G. W. Kattawar, 1968: Calculations of Reflected and Transmitted Radiance for Earth's Atmosphere, Ap. Op. 7.6.

Selby, J. E. A. and R. R. McClatchey, 1972: Atmospheric Transmittance from 0.25 to 28.5 μm: Computer Code LOWTRAN 2, AFCRL Environmental Research Papers, No. 427, AFCRL 72-0745.

NASA-JSC, (1973): Skylab Instrumentation Calibration Data. MSC-07744 Johnson Space Center, Houston, Texas.

Thekaekara, M. P. (ed), 1970: The Solar Constant and the Solar Spectrum Measured from a Research Aircraft, NASA TR R-351, Goodard Space Flight Center, Greenbelt, Maryland.

Figure 1. Input Parameters

SLANT PATH TO SPACE FROM ALTITUDE 0.0 KM ZENITH ANGLE = 37.55 DEGREES

MODEL ATMOSPHERE = 2 HAZE MODEL = 1 = 1.0 VISUAL RANGE

SOLAR ELEVATION ANGLE = 52.45 ASYMMETRY FACTOR = 1.00 DAY OF YEAR = 172. ORBITAL GEOMETRIC FACTOR = 1.033

WAVENUMBER 1	WAVELENGTH 2	SOLAR IRRADIANCE WATTS CM-2UM-1STR-1 3	ZENITH TRANSMISSIVITY 4	TRANSMISSIVITY AT SOLAR ELEV. ANGLE 5	SURFACE REFLECTANCE 6	ATMOSPHERIC REFLECTANCE AT SOLAR ELEV. ANGLE 7
25000.	0.400	0.14764	0.5110	0.4287	0.120	0.071
24500.	0.408	0.17688	0.5279	0.4467	0.124	0.069
24000.	0.417	0.18235	0.5445	0.4644	0.128	0.067
23500.	0.426	0.17432	0.5607	0.4820	0.133	0.065
23000.	0.435	0.17171	0.5764	0.4990	0.138	0.063
22500.	0.444	0.19731	0.5916	0.5157	0.143	0.061
22000.	0.455	0.21205	0.6066	0.5322	0.148	0.059
21500.	0.465	0.21155	0.6205	0.5477	0.153	0.057
21000.	0.476	0.21195	0.6339	0.5626	0.159	0.055
20500.	0.488	0.20264	0.6463	0.5766	0.165	0.053
20000.	0.500	0.20064	0.6574	0.5891	0.171	0.051
19500.	0.513	0.19157	0.6681	0.6012	0.178	0.050
19000.	0.526	0.19107	0.6771	0.6114	0.184	0.048
18500.	0.541	0.18388	0.6851	0.6206	0.192	0.046
18000.	0.556	0.17742	0.6923	0.6289	0.199	0.045
17500.	0.571	0.17709	0.6980	0.6354	0.207	0.042
17000.	0.588	0.17584	0.7097	0.6488	0.216	0.040
16500.	0.606	0.16990	0.7169	0.6571	0.225	0.037
16000.	0.625	0.16385	0.7322	0.6749	0.235	0.035
15500.	0.645	0.15775	0.7486	0.6940	0.245	0.032
15000.	0.667	0.15145	0.7634	0.7114	0.256	0.030
14500.	0.690	0.14494	0.0001	0.0001	0.268	0.028
14000.	0.714	0.13752	0.0001	0.0001	0.280	0.028
13500.	0.741	0.12998	0.0001	0.0001	0.294	0.031
13000.	0.769	0.12264	0.0001	0.0001	0.308	0.034
12500.	0.800	0.11458	0.0001	0.0001	0.324	0.037
12000.	0.833	0.10624	0.7529	0.7060	0.341	0.042
11500.	0.870	0.09793	0.0001	0.0001	0.359	0.046
11000.	0.909	0.09102	0.6887	0.6423	0.150	0.023
10500.	0.952	0.08605	0.3343	0.2845	0.150	0.024
10000.	1.000	0.07728	0.8472	0.8113	0.150	0.025
9500.	1.053	0.06859	0.8562	0.8221	0.150	0.025
9000.	1.111	0.05989	0.5758	0.5231	0.150	0.026
8500.	1.176	0.05249	0.8253	0.7891	0.150	0.026
8000.	1.250	0.04525	0.8751	0.8450	0.150	0.027
7500.	1.333	0.03830	0.4418	0.3899	0.150	0.028
7000.	1.429	0.03332	0.0570	0.0365	0.150	0.028
6500.	1.538	0.02807	0.8905	0.8641	0.150	0.029
6000.	1.667	0.02231	0.8911	0.8651	0.150	0.030
5500.	1.818	0.01578	0.0021	0.0001	0.150	0.030
5000.	2.000	0.01064	0.2630	0.2167	0.150	0.031
4500.	2.222	0.00792	0.0001	0.0001	0.150	0.032
4000.	2.500	0.00568	0.0150	0.0098	0.150	0.032

Figure 2.

COMPUTATION OF UNIT BAND BASS RADIANCES
UNITS, RADIANCES = WATTS*CM-2*UM-1*STR-1

WAVE-NUMBER	WAVE-LENGTH	THEORETICAL RADIANCE	ZERO AIR MASS RADIANCE	ATMOSPHERELESS RADIANCE	THEORETICAL CORRECTION	SURF,REF,CHANGE ZERO AIR MASS	SURF,REF,CHANGE NO ATMOSPHERE	MEASURED RADIANCE	CORRECTED RADIANCE
		1a	1b	1c	2	3b	3c	4	5
25000,	0,400	0,1155E-01	0,1976E-02	0,4610E-02	0,9575E-02	0,5813E 00	0,1807E 00	0,1155E-01	0,1976E-02
24500,	0,408	0,1360E-01	0,2553E-02	0,5715E-02	0,1105E-01	0,5373E 00	0,1713E 00	0,1360E-01	0,2553E-02
24000,	0,417	0,1379E-01	0,2832E-02	0,6097E-02	0,1096E-01	0,4973E 00	0,1621E 00	0,1379E-01	0,2832E-02
23500,	0,426	0,1298E-01	0,2908E-02	0,6034E-02	0,1007E-01	0,4605E 00	0,1531E 00	0,1298E-01	0,2908E-02
23000,	0,435	0,1260E-01	0,3071E-02	0,6155E-02	0,9525E-02	0,4272E 00	0,1442E 00	0,1260E-01	0,3071E-02
22500,	0,444	0,1428E-01	0,3777E-02	0,7325E-02	0,1050E-01	0,3965E 00	0,1354E 00	0,1428E-01	0,3777E-02
22000,	0,455	0,1515E-01	0,4341E-02	0,8157E-02	0,1081E-01	0,3682E 00	0,1268E 00	0,1515E-01	0,4341E-02
21500,	0,465	0,1495E-01	0,4619E-02	0,8434E-02	0,1033E-01	0,3425E 00	0,1183E 00	0,1495E-01	0,4619E-02
21000,	0,476	0,1482E-01	0,4929E-02	0,8761E-02	0,9891E-02	0,3188E 00	0,1099E 00	0,1482E-01	0,4929E-02
20500,	0,488	0,1404E-01	0,5010E-02	0,8689E-02	0,9031E-02	0,2970E 00	0,1015E 00	0,1404E-01	0,5010E-02
20000,	0,500	0,1379E-01	0,5260E-02	0,8928E-02	0,8528E-02	0,2773E 00	0,9308E-01	0,1379E-01	0,5260E-02
19500,	0,513	0,1308E-01	0,5321E-02	0,8851E-02	0,7756E-02	0,2588E 00	0,8478E-01	0,1308E-01	0,5321E-02
19000,	0,526	0,1296E-01	0,5606E-02	0,9169E-02	0,7355E-02	0,2420E 00	0,7627E-01	0,1296E-01	0,5606E-02
18500,	0,541	0,1241E-01	0,5692E-02	0,9172E-02	0,6720E-02	0,2263E 00	0,6772E-01	0,1241E-01	0,5692E-02
18000,	0,556	0,1192E-01	0,5788E-02	0,9203E-02	0,6131E-02	0,2112E 00	0,5883E-01	0,1192E-01	0,5788E-02
17500,	0,571	0,1169E-01	0,6074E-02	0,9559E-02	0,5620E-02	0,1919E 00	0,4633E-01	0,1169E-01	0,6074E-02
17000,	0,588	0,1151E-01	0,6412E-02	0,9883E-02	0,5096E-02	0,1716E 00	0,3550E-01	0,1151E-01	0,6412E-02
16500,	0,606	0,1099E-01	0,6539E-02	0,9951E-02	0,4448E-02	0,1531E 00	0,2343E-01	0,1099E-01	0,6539E-02
16000,	0,625	0,1062E-01	0,6755E-02	0,1001E-01	0,3866E-02	0,1344E 00	0,1436E-01	0,1062E-01	0,6755E-02
15500,	0,645	0,1031E-01	0,6980E-02	0,1006E-01	0,3332E-02	0,1170E 00	0,6184E-02	0,1031E-01	0,6980E-02
15000,	0,667	0,1001E-01	0,7178E-02	0,1009E-01	0,2835E-02	0,1011E 00	-,1937E-02	0,1001E-01	0,7178E-02
14500,	0,690	0,4014E-02	0,1010E-05	0,1010E-01	0,4013E-02	0,1064E 04	-,1613E 00	0,4014E-02	0,1013E-05
14000,	0,714	0,3875E-02	0,1003E-05	0,1003E-01	0,3874E-02	0,1083E 04	-,1720E 00	0,3875E-02	0,1003E-05
13500,	0,741	0,3975E-02	0,9937E-06	0,9937E-02	0,3974E-02	0,1175E 04	-,1763E 00	0,3975E-02	0,9947E-06
13000,	0,769	0,4136E-02	0,9839E-06	0,9839E-02	0,4135E-02	0,1296E 04	-,1787E 00	0,4136E-02	0,9872E-06
12500,	0,800	0,4291E-02	0,9660E-06	0,9660E-02	0,4290E-02	0,1439E 04	-,1801E 00	0,4291E-02	0,9686E-06
12000,	0,833	0,9425E-02	0,6656E-02	0,9427E-02	0,2769E-02	0,1419E 00	-,8664E-04	0,9425E-02	0,6656E-02
11500,	0,870	0,4513E-02	0,9161E-06	0,9161E-02	0,4512E-02	0,1770E 04	-,1824E 00	0,4513E-02	0,9164E-06
11000,	0,909	0,3695E-02	0,2282E-02	0,3555E-02	0,1413E-02	0,9286E-01	0,5991E-02	0,3695E-02	0,2282E-02
10500,	0,952	0,2381E-02	0,9556E-03	0,3359E-02	0,1425E-02	0,2237E 00	-,4367E-01	0,2381E-02	0,9556E-03
10000,	1,000	0,3973E-02	0,2447E-02	0,3017E-02	0,1526E-02	0,9353E-01	0,4758E-01	0,3973E-02	0,2447E-02
9500,	1,053	0,3614E-02	0,2201E-02	0,2677E-02	0,1413E-02	0,9630E-01	0,5248E-01	0,3614E-02	0,2201E-02
9000,	1,111	0,2252E-02	0,1223E-02	0,2338E-02	0,1029E-02	0,1262E 00	-,5499E-02	0,2252E-02	0,1223E-02
8500,	1,176	0,2724E-02	0,1617E-02	0,2049E-02	0,1107E-02	0,1027E 00	0,4943E-01	0,2724E-02	0,1617E-02
8000,	1,250	0,2533E-02	0,1493E-02	0,1766E-02	0,1040E-02	0,1045E 00	0,6508E-01	0,2533E-02	0,1493E-02
7500,	1,333	0,1320E-02	0,5829E-03	0,1495E-02	0,7369E-03	0,1896E 00	-,1758E-01	0,1320E-02	0,5829E-03
7000,	1,429	0,9478E-03	0,4747E-04	0,1301E-02	0,9004E-03	0,2845E 01	-,4068E-01	0,9478E-03	0,4747E-04
6500,	1,538	0,1657E-02	0,9468E-03	0,1096E-02	0,7103E-03	0,1125E 00	0,7685E-01	0,1657E-02	0,9468E-03
6000,	1,667	0,1332E-02	0,7532E-03	0,8707E-03	0,5788E-03	0,1153E 00	0,7948E-01	0,1332E-02	0,7532E-03
5500,	1,818	0,4786E-03	0,6158E-07	0,6158E-03	0,4786E-03	0,1166E 04	-,3342E-01	0,4786E-03	0,6170E-07
5000,	2,000	0,3541E-03	0,9001E-04	0,4154E-03	0,2641E-03	0,4401E 00	-,2213E-01	0,3541E-03	0,9001E-04
4500,	2,222	0,2517E-03	0,3093E-07	0,3093E-03	0,2517E-03	0,1220E 04	-,2794E-01	0,2517E-03	0,3097E-07
4000,	2,500	0,1846E-03	0,2174E-05	0,2218E-03	0,1824E-03	0,1259E 02	-,2518E-01	0,1846E-03	0,2174E-05

Figure 3.

COMPUTATION OF S192 CHANNEL WEIGHTED RADIANCES

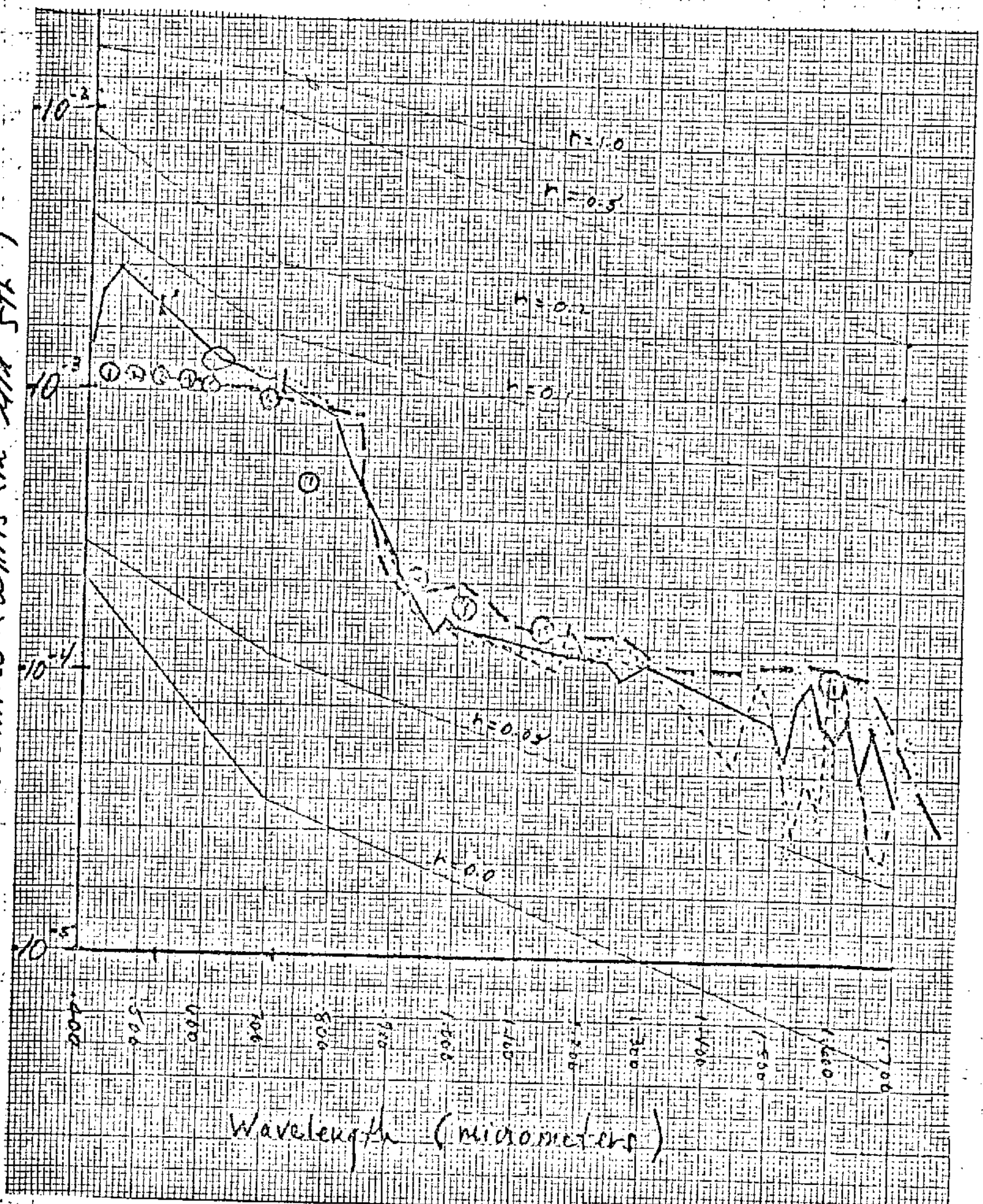
CHANNEL#	GNU-BAR	CHANNEL LIMITS	THEORETICAL RADIANCE	ZERO AIR MASS RADIANCE	ATMOSPHERELESS RADIANCE	THEORETICAL CORRECTION	SURF.REF.CHANGE ZERO AIR MASS	SURF.REF.CHANGE NO ATMOSPHERE	MEASURED RADIANCE	CORRECTED RADIANCE
1	23061.	20900. 25000.	0.1380E-01	0.3374E-02	0.1381E-01	0.1043E-01	0.4357E 00	0.1455E 00	0.1380E-01	0.3374E-02
2	21406.	18600. 23800.	0.1427E-01	0.4496E-02	0.1427E-01	0.9769E-02	0.3429E 00	0.1169E 00	0.1427E-01	0.4496E-02
3	19592.	17300. 21700.	0.1336E-01	0.5349E-02	0.1337E-01	0.8013E-02	0.2642E 00	0.8613E-01	0.1336E-01	0.5349E-02
4	18176.	15900. 20400.	0.1219E-01	0.5826E-02	0.1219E-01	0.6360E-02	0.2147E 00	0.6037E-01	0.1219E-01	0.5826E-02
5	16983.	15000. 18500.	0.1135E-01	0.6333E-02	0.1136E-01	0.5020E-02	0.1717E 00	0.3522E-01	0.1135E-01	0.6333E-02
6	15268.	13400. 16900.	0.9810E-02	0.6571E-02	0.9820E-02	0.3239E-02	0.6496E 02	-.7557E-02	0.9810E-02	0.6571E-02
7	13198.	10000. 15100.	0.7111E-02	0.3993E-02	0.7112E-02	0.3117E-02	0.5161E 03	-.7851E-01	0.7111E-02	0.3993E-02
8	10739.	9100. 12900.	0.4066E-02	0.1858E-02	0.4071E-02	0.2209E-02	0.4091E 03	-.3346E-01	0.4066E-02	0.1858E-02
9	9726.	7700. 11100.	0.3322E-02	0.1930E-02	0.3324E-02	0.1392E-02	0.1718E 02	0.2767E-01	0.3322E-02	0.1930E-02
10	8816.	7200. 10500.	0.2721E-02	0.1536E-02	0.2723E-02	0.1185E-02	0.1659E 02	0.3119E-01	0.2721E-02	0.1536E-02
11	6348.	5400. 7800.	0.1156E-02	0.4789E-03	0.1169E-02	0.6766E-03	0.3196E 03	0.2366E-01	0.1156E-02	0.4789E-03
12	4481.	4000. 5200.	0.3586E-03	0.1420E-03	0.3631E-03	0.2167E-03	0.3078E 03	0.2557E-01	0.3586E-03	0.1420E-03

Figure 4. RADIANCE VS. WAVELENGTH CALCULATIONS

THEORY*: SUMMER MIDLATITUDE ATMOSPHERE
PARAMETERS FOR PASS 43
UNIT BAND PASS - - -
THEORETICAL S192 ①, ②, ③.... (channel nos.)

*[ALL CALCULATIONS PLOTTED x 10⁻¹]

DATA: S191 RADIANCES PASS 43 SALTON SEA - DESERT
SEGMENT 18:05:7.82 - 8.75 ———
18:05:12.46 - 13.38 - - - - -
18:05:10.60 - 11.53 ....



K+E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 1320